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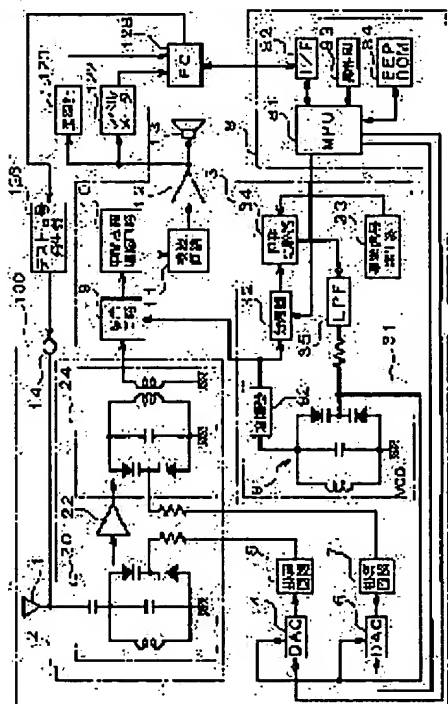
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(54) RECEIVER AND ITS TRACKING ADJUSTING METHOD



(57)Abstract:

PROBLEM TO BE SOLVED: To provide a receiver which can shorten the time required for tracking adjustment, does not require temperature compensation, and can prevent increase of tracking errors caused by the fluctuation of the power supply voltage, and to provide a method with which the tracking of the receiver can be adjusted.

SOLUTION: A DAC 4 generates voltage corresponding to the value of data D0 inputted from an MPU 81, by using a control voltage outputted from a low-pass filter 35 incorporated in a local oscillator 3 as a reference voltage for digital-to-analog conversion. A multiplication circuit 5 performs analog multiplication on the output voltage of the DAC 4 by using a prescribed multiplier. The output voltage of the circuit 5 is impressed upon a high-frequency tuning circuit 20 as a tuning voltage. The value of input data D0 of the DAC 4 corresponding to the tuning voltage, when the tracking error becomes a minimum at the medium value of a local oscillation

frequency is measured and is stored in advance in an EEPROM 84; and the MPU 81 read the data D0 from the EEPROM 84 and inputs the data D0 to the DAC 4.

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CLAIMS

[Claim(s)]

[Claim 1] The RF receiving circuit which receives the broadcast wave of received frequency according to tuning voltage, The mixing circuit which mixes the local oscillator which generates the local oscillation signal of the frequency according to control voltage, the signal outputted from said RF receiving circuit, and said local oscillation signal, and outputs the intermediate frequency signal corresponding to the number of difference subharmonics, The offset circuit which sets up predetermined offset voltage to said control voltage, The receiver characterized by having the multiplication circuit which performs analog multiplication of a predetermined multiplier to said control voltage, and being impressed by said RF receiving circuit by making into said tuning voltage the electrical potential difference which let said control voltage pass in said offset circuit and said multiplication circuit.

[Claim 2] It is the receiver characterized by setting up based on the adjustable range of the frequency of said local oscillation signal which generates the multiplier of said multiplication circuit with said local oscillator in claim 1, and the adjustable range of the received frequency of said RF receiving circuit.

[Claim 3] It is the receiver which said offset circuit is a digital-to-analog converter in claims 1 or 2, and is characterized by setting up said offset voltage by adjusting input data while using said control voltage as reference voltage.

[Claim 4] It is the receiver characterized by being set up so that a tracking error may serve as min, when it is set as the any value in which said offset voltage is contained in the adjustable range in the frequency of said local oscillation signal in claim 3.

[Claim 5] It is the receiver characterized by being set up so that two or more values to which said offset voltage is changed in claim 4 according to the frequency of said local oscillation signal may be prepared and the tracking error corresponding to the whole region of the adjustable range of the frequency of said local oscillation signal may become below a predetermined value.

[Claim 6] The memory which stores said input data required for generation of said offset voltage set up in claim 3 so that the tracking error corresponding to the whole region of the adjustable range of the frequency of said local oscillation signal might become below a predetermined value, The receiver characterized by having an electrical-potential-difference value setting means to set

up the value of said offset voltage corresponding to the frequency of said local oscillation signal by reading said input data stored in said memory, and inputting into said digital-to-analog converter.

[Claim 7] While being the tracking adjustment approach of performing tracking adjustment of one receiver of claims 1-6 and setting the received frequency of said receiver as the any value contained in the adjustable range The 1st step which inputs into said RF receiving circuit the predetermined test signal which has the same frequency as the received frequency at this time, The tracking adjustment approach of the receiver characterized by having the 2nd step which sets up the value of said offset voltage set up by said offset circuit so that the tracking error of said receiver after various kinds of setup was performed in said 1st step may serve as min.

[Claim 8] The receiver characterized by having the 3rd step which changes and sets up the value of said offset voltage about some frequency bands where these upper limits or lower limits are contained in claim 7 when a tracking error [/ near said adjustable range a upper limit or near the lower limit] is large.

[Claim 9] While setting the received frequency of said receiver as the any value contained in the adjustable range in the tracking adjustment approach of performing tracking adjustment of the receiver of claim 6 So that the tracking error of said receiver after various kinds of setup was performed in the 4th step which inputs into said receiver the predetermined test signal which has the same frequency as the received frequency at this time, and said 4th step may serve as min The tracking adjustment approach of the receiver characterized by having the 5th step which sets up the input data of said digital-to-analog converter, and the 6th step which stores in said memory said input data set up in said 5th step.

[Claim 10] The tracking adjustment approach of the receiver characterized by to have the 7th step which changes and sets up the contents of the input data of said digital-to-analog converter about some frequency bands where these upper limits or lower limits are contained, and the 8th step which stores in said memory the input data of said digital-to-analog converter after modification set up in said 7th step in claim 9 when a tracking error [/ near said adjustable range a upper limit or near the lower limit] is large.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the receiver which adopted the TERODAIN method to the supermarket, and its tracking adjustment approach.

[0002]

[Description of the Prior Art] Generally, in the receiver which receives broadcast waves, such as AM broadcast and FM broadcasting, the superheterodyne system is adopted as the receiving method. the description that are the receiving method which changes a superheterodyne system into the intermediate frequency signal which has the fixed frequency for which it does not depend on the frequency (received frequency) of an input signal by mixing a predetermined local-oscillation signal to the received broadcast signal, performs detection processing, magnification, etc. after that, and reproduces a sound signal, and sensibility, selectivity, etc. are excellent compared with other receiving methods -- **** -- it is.

[0003] Drawing 8 is drawing showing the configuration of the conventional receiver which adopted the superheterodyne system. The conventional receiver shown in this drawing is constituted including an antenna 200, the RF receiving circuit 202, a local oscillator 204, a mixing circuit 206, the intermediate frequency amplifying circuit 208, MPU210, memory 212, the control unit 214, and the digital-to-analog converter (DAC) 216.

[0004] In the conventional receiver, the data in which the relation of the tuning voltage and received frequency which are impressed to the high frequency receiving circuit 202 is shown are stored in memory 212. MPU210 computes data required in order to generate tuning voltage based on the data stored in memory 212, and inputs them into DAC216. The tuning voltage which has a desired value is generated by this DAC216, and it is impressed by the RF tuning circuit 202.

[0005] Drawing 9 is drawing showing the contents of the data stored in memory 212. As shown in this drawing, it is the adjustable range of received frequency f_0 - f_5 . If it carries out For example, some received frequency f_0 and f_1 , in this adjustable within the limits f_2 , f_3 , f_4 , and f_5 . The corresponding tuning voltage V_0 , V_1 , V_2 , V_3 , V_4 , and V_5 . It is measured beforehand and the input data of DAC216 required in order to generate the tuning voltage of these plurality is stored in memory 212. And f_0 which mentioned above the received frequency of the RF receiving circuit 202, f_1 , f_2 , f_3 , f_4 , and f_5 . In setting it as the value of an except, MPU210 asks for input data required in order to read the input data of DAC216 corresponding to two received frequency of the near from memory 212, to perform a linear interpolation operation and to generate desired received frequency, and inputs this into DAC216. Thus, predetermined tuning voltage is impressed to the RF receiving circuit 202 from DAC216, and desired received frequency is set up.

[0006]

[Problem(s) to be Solved by the Invention] By the way, when you made it the oscillation frequency of a local oscillator 204 interlocked with using the conventional method mentioned above and the tuning frequency of the RF receiving circuit 202 was set up, problems, such as being weak, were in the fluctuation of (3) supply voltage with difficult (2) temperature compensation which requires time amount for (1) tracking adjustment.

[0007] Two or more tuning voltage V_0 as mentioned above, in order to set up suitable tuning voltage using DAC216, as shown in drawing 9, V_1 , V_2 , V_3 , V_4 , and V_5 . It is necessary to perform tracking adjustment measured beforehand. For example, tuning voltage V_0 . Measuring is tuning frequency f_0 . Tuning voltage V_0 from which it is in the condition which outputted the corresponding local oscillation signal of a frequency from the local oscillator 204, adjustable [of the value of the input data of DAC216] is carried out, and a tracking error becomes min. It will ask. Usually, it is measured using the distortion meter and the level meter whether a tracking error is min, and in order that the distortion-rate measurement using a distortion meter may wait for the stability of an output value, the time amount for about 10 - 20 seconds is needed. Since such measurement is needed for every tuning voltage, the time amount concerning tracking adjustment becomes long.

[0008] Moreover, generally, since the property of a component that the RF receiving circuit 202 is used changes with temperature, even if the tuning voltage outputted from DAC216 is fixed, tuning frequency changes with temperature. On the other hand, since a local oscillator 204 generally has a PLL (phase-locked loop) configuration containing a voltage controlled oscillator or a variable divider, even if the property of the component used changes with temperature, the frequency of the local oscillation signal decided by the division ratio of a variable divider does

not change. Thus, a temperature change is interlocked with, only tuning frequency changes, and since the frequency of a local oscillation signal does not change, a tracking error increases in connection with a temperature change. Although it is necessary to have a temperature-compensation circuit independently in order to avoid such un-arranging, temperature compensation is performed in the whole region of tuning frequency, and preventing increase of a tracking error also newly produces the problem that it will not be easy and a circuit scale will moreover become large.

[0009] Furthermore, since the output voltage of DAC216 is interlocked with the fall of supply voltage and becomes low when changing the supply voltage of the receiver shown in drawing 8 (for example, when the driver voltage falls in the car radio driven with the pocket receiver driven by the cell, or a mounted dc-battery), even if MPU210 tends to set up desired tuning frequency, tuning voltage falls, and a tracking error becomes large.

[0010] This invention is created in view of such a point, the purpose can shorten the time amount which tracking adjustment takes, temperature compensation is unnecessary, and it is in offering the receiver which can prevent increase of the tracking error by fluctuation of supply voltage, and its tracking adjustment approach.

[0011]

[Means for Solving the Problem] In order to solve the technical problem mentioned above, the receiver of this invention is equipped with a RF receiving circuit, the local oscillator, the mixing circuit, the offset circuit, and the multiplication circuit. A RF receiving circuit receives the broadcast wave of the received frequency according to tuning voltage. A local oscillator generates the local oscillation signal of the frequency according to control voltage. A mixing circuit mixes the signal and local oscillation signal which are outputted from a RF receiving circuit, and outputs the intermediate frequency signal corresponding to the number of difference subharmonics. An offset circuit sets up predetermined offset voltage to control voltage. A multiplication circuit performs analog multiplication of a predetermined multiplier to control voltage. The receiving circuit of this invention is impressed to a RF receiving circuit by these configurations by making into tuning voltage the electrical potential difference which let control voltage pass in the offset circuit and the multiplication circuit.

[0012] Since tuning voltage is generated based on control voltage, like the conventional receiver using a digital-to-analog converter, a tracking error does not need to ask for two or more tuning voltage used as min by measurement, and can shorten the time amount which tracking adjustment takes.

[0013] Moreover, as for the multiplier of the multiplication circuit mentioned above, it is desirable to set up based on the adjustable range of the frequency of the local oscillation signal generated with a local oscillator and the adjustable range of the received frequency of a RF receiving circuit. Although the adjustable width of face of control voltage and the adjustable width of face of tuning voltage corresponding to these adjustable range do not become the same even if the center frequency of the adjustable range of a local oscillation signal and the center frequency of the adjustable range of the received frequency of a RF receiving circuit are the cases where each adjustable width of face is made in agreement since it has shifted by the intermediate frequency, a difference of the adjustable width of face of each [these] electrical potential difference can be made in agreement by carrying out the analog multiplication of the predetermined multiplier to control voltage.

[0014] Moreover, it is desirable to set up offset voltage by realizing the offset circuit mentioned above by the digital-to-analog converter using control voltage as reference voltage, and adjusting

input data. Since it can carry out adjustable [of the value of offset voltage] by adjusting the value of digital input data, offset voltage can be adjusted now using a processor etc. and the time and effort which a setup of offset voltage takes can be reduced. Moreover, since the value of the tuning voltage impressed to a RF receiving circuit is also interlocked with control voltage and is changed when ambient temperature changes and the value of control voltage is changed, temperature compensation can be performed only by making a RF receiving circuit and a local oscillator a similar configuration, and the temperature compensation by the complicated circuit becomes unnecessary.

[0015] Moreover, when the frequency of a local oscillation signal is set as the any value contained in the adjustable range, as for the offset voltage mentioned above, it is desirable to set up so that a tracking error may serve as min. The time amount which this adjustment takes can be shortened by reducing the count of the tracking adjustment performed using a distortion meter etc.

[0016] Moreover, as for offset voltage, it is desirable to prepare two or more values changed according to the frequency of a local oscillation signal, and to set up so that the tracking error corresponding to the whole region of the adjustable range of the frequency of a local oscillation signal may become below a predetermined value. Although optimal tracking adjustment in the central value of the frequency adjustable range of a local oscillation signal is performed and the predetermined offset voltage corresponding to the frequency range of this near is set up, there is an inclination for a tracking error to become large as the frequency of a local oscillation signal shifts from this central value. For this reason, in the whole region of the frequency adjustable range, a tracking error can be easily made small by dividing the whole region of the frequency adjustable range of a local oscillation signal into two or more fields, setting up the offset voltage which has a different value for every partition field, and changing offset voltage for every partition field.

[0017] Moreover, it is desirable to have an electrical-potential-difference value setting means to set up the value of the offset voltage corresponding to the frequency of a local oscillation signal by reading the input data stored in the memory which stores input data required for generation of the offset voltage set up so that the tracking error corresponding to the whole region of the adjustable range of the frequency of the local oscillation signal mentioned above might become below a predetermined value, and this memory, and inputting into a digital-to-analog converter. Since the optimal offset voltage is generable by reading the input data stored in memory and inputting into a digital-to-analog converter, a setup of the offset voltage after the optimal adjustment was made becomes easy.

[0018] Moreover, by the tracking adjustment approach of the receiver of this invention, in the 1st step, while setting the received frequency of a receiver as the any value contained in that adjustable range, the predetermined test signal which has the same frequency as the received frequency at this time is inputted into a RF receiving circuit. In the 2nd step, the value of the offset voltage set up by the offset circuit is set up so that the tracking error of the receiver after various kinds of setup was performed in the 1st step may serve as min. Since measurement of a tracking error is carried out in the any value contained in the adjustable range of received frequency, the time amount which tracking adjustment takes can be shortened by reducing the count of this measurement.

[0019] Moreover, it is desirable to have the 3rd step which changes and sets up the value of offset voltage after the 2nd step mentioned above about some frequency bands where these upper limits or lower limits are contained when a tracking error [/ near the received frequency of the

adjustable range a upper limit or near the lower limit] is large. Although it is only by the tracking adjustment in one any value also when the tracking error in the whole receiving band does not become below a predetermined value, the tracking error in the whole receiving band can be easily stopped in predetermined tolerance by changing the value of the offset voltage corresponding to some frequency bands containing the upper limit or lower limit of received frequency to which a tracking error becomes large most.

[0020] Moreover, by the tracking adjustment approach of the receiver of this invention, in the 4th step, while setting the received frequency of a receiver as the any value contained in that adjustable range, the predetermined test signal which has the same frequency as the received frequency at this time is inputted into a receiver. In the 5th step, the input data of a digital-to-analog converter is set up so that the tracking error of the receiver after various kinds of setup was performed in the 4th step may serve as min. In the 6th step, the input data set up in the 5th step is stored in memory. Since measurement of a tracking error is carried out in the any value contained in the adjustable range of received frequency, the time amount which tracking adjustment takes can be shortened by reducing the count of this measurement. Moreover, since the result of tracking adjustment is stored in memory, as a result, preservation and the use which can be set after that of data become easy.

[0021] Moreover, it is desirable to have the 7th step which changes and sets up the contents of the input data of a digital-to-analog converter after the 6th step mentioned above about some frequency bands where these upper limits or lower limits are contained when a tracking error [/ near the adjustable range a upper limit or near the lower limit] is large, and the 8th step which stores in memory the input data of the digital-to-analog converter after modification set up in this 7th step. Only by setting up the offset voltage which has the whole receiving band value common about *****, when a tracking error cannot be controlled below to a predetermined allowed value, it is necessary to set up two or more offset voltage which has a different value but, and in order for what is necessary just to be to store the data corresponding to the value of two or more offset voltage in memory even if it is such a case, preservation and use of data become easy as a result of tracking adjustment.

[0022]

[Embodiment of the Invention] Hereafter, the FM receiver of 1 operation gestalt which applied this invention is explained, referring to a drawing. Drawing 1 is drawing showing the configuration of the FM receiver of this operation gestalt. FM receiver 100 shown in this drawing is constituted including an antenna 1, the high frequency receiving circuit 2, the digital-to-analog converter (DAC) 4 of 3 or 2 local oscillators, 6 or 2 multiplication circuits 5 and 7, a control section 8, a mixing circuit 9, the intermediate frequency amplifying circuit 10, the detector circuit 11, the low frequency amplifying circuit 12, and the loudspeaker 13.

[0023] The RF receiving circuit 2 performs RF magnification to the signal after alignment, and is constituted including two RF tuning circuits 20 and 24 and RF amplifying circuits 22 while performing alignment actuation which passes only the component near [predetermined] the tuning frequency alternatively to the broadcast wave inputted from an antenna 1.

[0024] Selectivity is raised by amplifying the output of the RF tuning circuit 20 of the first rank where the antenna 1 was connected in the RF amplifying circuit 22, and letting the magnification output pass to the 2nd step of RF tuning circuit 24 further. Moreover, the variable capacitance diode for carrying out adjustable [of the tuning frequency] is contained in each of two RF tuning circuits 20 and 24, and by changing the tuning voltage of the reverse bias impressed to variable capacitance diode, the tuning frequency of each RF tuning circuits 20 and 24 interlocks,

and is changed. That is, in the RF receiving circuit 2, the broadcast wave of received frequency (tuning frequency) according to the tuning voltage impressed to two RF tuning circuits 20 and 24 is chosen.

[0025] The local oscillator 3 is constituted including a voltage controlled oscillator (VCO) 31, the counting-down circuit 32, the reference signal generator 33, the phase comparator 34, and the low pass filter (LPF) 35. VCO31 performs oscillation actuation of the frequency corresponding to the control voltage generated with a low pass filter 35, outputs a local oscillation signal, and is equipped with the VCO resonance circuit 91 and amplifier 92. The VCO resonance circuit 91 is a parallel resonant circuit which consists of an inductor and a capacitor, and two variable capacitance diodes for carrying out adjustable [of the resonance frequency] are connected to a capacitor and juxtaposition. And when the capacity of variable capacitance diode changes according to the control voltage of the reverse bias impressed, the resonance frequency of the VCO resonance circuit 91 changes. Moreover, amplifier 92 performs predetermined magnification actuation required for an oscillation.

[0026] By the predetermined division ratio N, a counting-down circuit 32 carries out dividing of the local oscillation signal inputted from VCO31, and outputs it. The value of a division ratio N is set as adjustable by the control section 8. The reference signal generator 33 outputs the reference signal of the high predetermined frequency of frequency stability. A phase comparator 34 compares a phase between the reference signal outputted from the reference signal generator 33, and the signal (local oscillation signal after dividing) outputted from a counting-down circuit 32, and outputs the error signal of the shape of a pulse according to phase contrast. A low pass filter 35 generates control voltage by removing and graduating the high frequency component of the error signal of the shape of a pulse outputted from a phase comparator 34. Such VCO31, a counting-down circuit 32, a phase comparator 34, and a low pass filter 35 are connected in the shape of a loop formation, and PLL (phase-locked loop) is constituted.

[0027] In addition, what has the property of electrical-potential-difference pair capacity almost the same [each of the variable capacitance diode contained in each of the RF tuning circuits 20 and 24 in the RF receiving circuit 2 mentioned above and the variable capacitance diode contained in the VCO resonance circuit 91 in a local oscillator 3] is used.

[0028] DAC4 and the multiplication circuit 5 are used in order to generate the tuning voltage impressed to the RF tuning circuit 20 in the RF receiving circuit 2. Specifically, DAC4 of this operation gestalt generates the electrical potential difference according to the value of the digital data inputted from a control section 8, using the control voltage Vc outputted from the low pass filter 35 in a local oscillator 3 as reference voltage at the time of digital to analog. In addition, in future explanation, the digital data inputted from a control section 8 to each of DACs 4 and 6 shall be called "DAC input data."

[0029] When n-bit DAC input data D is inputted by the control section 8, the output voltage Va of DAC4 is expressed like a degree type.

$$V_a = V_{cx} (D/2^n) \text{ -- (1)}$$

(1) In a formula, when the value of DAC input data D inputted into DAC4 shall be fixed to a predetermined value, the output voltage Va of DAC4 will change according to the control voltage Vc outputted from a low pass filter 35. In addition, about the approach of setting up the value of the DAC input data inputted into DAC4, it mentions later.

[0030] The multiplication circuit 5 performs analog multiplication of the predetermined multiplier K to the output voltage Va of DAC4. Specifically, the output voltage Vr of the multiplication circuit 5 is expressed like a degree type.

$V_r = V_a \times K$ -- (2)

Some candidate values, such as "1", "1.5", and "2", are prepared, and the multiplier K of this multiplication circuit 5 can set one of values now as arbitration. And the value of a multiplier K is set up based on the adjustable range of the frequency of a local oscillation signal, and the adjustable range of the received frequency in the RF receiving circuit 2. With this operation gestalt, the frequency of the local oscillation signal outputted from a local oscillator 3 If it is set as the value higher 10.7MHz than the received frequency in the RF receiving circuit 2 and is going to make in agreement the adjustable range of received frequency, and the adjustable range of the frequency of a local oscillation signal It is necessary to set up greatly the adjustable range of the tuning voltage impressed to the RF receiving circuit 2 rather than the adjustable range of the control voltage generated within a local oscillator 3, for this reason the multiplication circuits 5 and 7 are used. The output voltage V_r of the multiplication circuit 5 is impressed to the RF tuning circuit 20 as tuning voltage V_{t1} .

[0031] Moreover, DAC6 and the multiplication circuit 7 are used in order to generate the tuning voltage impressed to the RF tuning circuit 24 in the RF receiving circuit 2. DAC6 outputs the DAC input data inputted from a control section 8, and the output voltage V_a according to the control voltage V_c outputted from a low pass filter 35 like DAC4 mentioned above. The multiplication circuit 7 performs analog multiplication of the predetermined multiplier K to the output voltage V_a of DAC6 like the multiplication circuit 5 mentioned above. The output voltage V_r of the multiplication circuit 7 is impressed to the RF tuning circuit 24 as tuning voltage V_{t2} .

[0032] DACs 4 and 6 mentioned above support the offset circuit, and the difference of the output voltage in each of these DACs 4 and 6 and input voltage supports offset voltage. A control section 8 controls actuation by whole FM receiver 100, and is constituted including MPU81, the interface section (I/F) 82, the control unit 83, and EEPROM84.

[0033] According to the set point of the received frequency inputted from a control unit 83, the division ratio N of the counting-down circuit 32 in a local oscillator 3 is set up, or MPU81 performs predetermined control action of setting up the DAC input data corresponding to each of DACs 4 and 6. The interface section 82 is for connecting between external PC (personal computer)128 and MPU81 in a control section 8. Various directions can be given from PC128 to MPU81 through this interface section 82.

[0034] The control unit 83 is equipped with various kinds of actuation keys, and it is used in order to perform a setup of received frequency etc. EEPROM84 is the memory which can perform a data storage and elimination electrically, and stores DAC input data required in order to generate predetermined offset voltage.

[0035] A mixing circuit 9 mixes the input signal outputted from the RF receiving circuit 2, and the local oscillation signal outputted from a local oscillator 3, and outputs the signal corresponding to the difference component. The intermediate frequency amplifying circuit 10 generates an intermediate frequency signal by passing only the frequency component near [predetermined] the intermediate frequency (10.7MHz) while amplifying the signal outputted from a mixing circuit 9.

[0036] A detector circuit 11 performs detection processing to the intermediate frequency signal outputted from the intermediate frequency amplifying circuit 10, and restores to a sound signal. The low frequency amplifying circuit 12 amplifies the sound signal outputted from a detector circuit 11 by predetermined gain. A loudspeaker 13 performs a voice output based on the sound signal after the magnification outputted from the low frequency amplifying circuit 12.

[0037] The test signal input terminal 14 is for inputting the test signal of predetermined

frequency, in order to perform tracking adjustment. The test signal inputted through this test signal input terminal 14 is inputted into the RF receiving circuit 2. Moreover, each of the 120 level meter distortion meter 122 shown in drawing 1, the test signal generator 126, and PC128 is used in order to perform predetermined tracking adjustment which sets up the value of the DAC input data inputted into DACs 4 and 6 in FM receiver 100 mentioned above.

[0038] A distortion meter 120 measures a distortion rate based on the sound signal after the magnification outputted from the low frequency amplifying circuit 12 in FM receiver 100. A level meter 122 measures the signal level of the sound signal after the magnification outputted from the low frequency amplifying circuit 12. Drawing 2 is drawing showing the relation between a distortion meter 120, and the output value of a level meter 122 and an aligning point. In this drawing, a left-hand side axis of ordinate supports to the output value of a level meter 122, and the right-hand side axis of ordinate supports [the axis of abscissa] the output value of a distortion meter 120 at tuning frequency, respectively. Moreover, Curve a shows the situation of the change of Curve b of the output value of a level meter 122 by the situation of change of the output value of a distortion meter 120, respectively.

[0039] As shown in drawing 2, at the optimal aligning point shown by the dotted line near the center, the output value (distortion rate) of a distortion meter 120 serves as min, and the output value of a level meter 122 serves as max. Therefore, in order to investigate the tuning voltage corresponding to the optimal aligning point, what is necessary will be just to detect tuning voltage from which the output value of a level meter 122 serves as max, but since the degree of change [/ near the aligning point of the output value of a level meter 122] is gently-sloping, it is not easy to extract the optimal aligning point. For this reason, tuning voltage from which the output value of a distortion meter 120 usually serves as min was detected, and it has set up as tuning voltage corresponding to the optimal aligning point. However, in order not to detect the aligning point mistaken by such condition since the output value of a distortion meter 120 served as min also in a non-signal state, it is necessary to also refer to the output value of a level meter 122.

[0040] The test signal generator 126 outputs the test signal generated by applying FM modulation to the subcarrier of predetermined frequency based on the directions from PC128. This test signal is inputted into the RF amplifying circuit 2 in FM receiver 100 through the test signal input terminal 14 mentioned above.

[0041] PC128 controls a series of actuation which performs tracking adjustment. Specifically, PC128 sets the received frequency of FM receiver 100 as the frequency of a test signal by setting the division ratio of the counting-down circuit 32 in a local oscillator 3 as a predetermined value while it sends directions to the test signal generator 126 and inputs a predetermined test signal into FM receiver 100. Moreover, in this condition, PC128 reads each output value of a distortion meter 120 and a level meter 122, carrying out adjustable [of the value of the DAC input data inputted into each of DACs 4 and 6], and measures the DAC input data with which the output value of a level meter 122 is beyond a predetermined value, and the output value of a distortion meter 120 serves as min. The DAC input data called for by this measurement is sent to the control section 8 of FM receiver 100, and is stored in EEPROM84 by MPU81. MPU81 mentioned above corresponds to an electrical-potential-difference value setting means. About the detailed level procedure of tracking adjustment, it mentions later.

[0042] FM receiver 100 of this operation gestalt explains the detail of the tracking adjustment actuation which has such a configuration, next is performed with PC128. Drawing 3 and drawing 4 are the flow charts showing the operations sequence of the tracking adjustment performed by

control of PC128. In addition, since two DACs 4 and 6 set as the object of tracking adjustment are contained in FM receiver 100 of this operation gestalt, the case where tracking adjustment is performed paying attention to one of DACs is explained.

[0043] First, PC128 sends directions to the test signal generator 126, and inputs the test signal of the same frequency as the center frequency of the adjustable range of the received frequency of FM receiver 100 into FM receiver 100 (step 100). For example, considering the case where the received frequency band of FM receiver 100 is 76.0-90.0MHz, the 83.0MHz test signal which is the same frequency as the center frequency of this adjustable range is generated by the test signal generator 126, and is inputted into the test signal input terminal 14 of FM receiver 100.

[0044] Moreover, PC128 sends directions to a control section 8, and it sets them up so that the oscillation frequency (local oscillation frequency) of a local oscillator 3 may turn into a frequency corresponding to the center frequency of the adjustable range of the received frequency of FM receiver 100 (step 101). For example, in FM receiver 100 of this operation gestalt, if the local oscillation signal which has a frequency higher 10.7MHz than received frequency shall be used, the division ratio of the counting-down circuit 32 required in order to generate the local oscillation frequency of 93.7MHz will be set up.

[0045] Thus, after the input of a test signal and a setup of a local oscillation frequency are completed, PC128 is the value D0 of the DAC input data with which adjustable [of the value of the DAC input data corresponding to one DAC4] is carried out in the predetermined range, and a tracking error serves as min next. It measures and (step 102) and this measured value are written in EEPROM84 in a control section 8 (step 103). If it is set as the optimal aligning point and a tracking error becomes min, as mentioned above, since the output value of a distortion meter 120 will also serve as min, PC128 carries out adjustable [of the value of DAC input data] to an one direction, and measures the value of the DAC input data with which the output value of this distortion meter 120 becomes the smallest. Moreover, at this time, the output value of a level meter 122 checks that it is beyond a predetermined value, and PC128 performs a predetermined error message, when it is below a predetermined value.

[0046] Drawing 5 is drawing showing the relation between a local oscillation frequency and tuning frequency. When there is no tracking error in the whole region of a receiving band, and it carries out adjustable [of the local oscillation frequency], since tuning frequency is set as a frequency lower 10.7MHz than this, a local oscillation frequency and tuning frequency serve as relation as shown in the straight line c in drawing 5 . However, since the tracking error which generally originates in each circuitry of a local oscillator 3 and the RF receiving circuit 2, the difference between an oscillation frequency and tuning frequency, etc. occurs, it will have the relation of a different curve d from the straight line c mentioned above.

[0047] DAC input data D0 which makes the output value of a distortion meter 120 min in measurement of step 102 mentioned above when a local oscillation frequency is doubled with the center frequency of the adjustable range Since it has measured, This DAC input data D0 By being impressed by the RF tuning circuit 20 by making that output voltage into tuning voltage V_{t1} , after letting the electrical potential difference which corresponds and is generated by DAC4 pass in the multiplication circuit 5 The tracking error corresponding to this local oscillation frequency and tuning frequency can be made into min. That is, the relation of a local oscillation frequency and tuning frequency as shown in the curve e of drawing 5 can be filled by measuring step 102 and setting up the value of the DAC input data corresponding to one DAC4.

[0048] Next, PC128 performs processing which changes the value of DAC input data in the frequency range where this band is included, when it investigates [the whole receiving band]

whether a tracking error becomes below a predetermined value about ***** and a tracking error becomes large in some frequency bands.

[0049] First, PC128 sends directions to the test signal generator 126, and, specifically, inputs the test signal of the same frequency as the upper limit of the adjustable range of the received frequency of FM receiver 100 into FM receiver 100 (step 104). Moreover, PC128 sends directions to a control section 8, and is the upper limit f_{max} of the adjustable range of a local oscillation frequency. The value of a local oscillation frequency is set up so that it may become a corresponding frequency (step 105).

[0050] Thus, after various kinds of setup corresponding to the upper limit of received frequency is completed, PC128 incorporates the output value of a level meter 122, and judges whether this value is beyond a predetermined value (step 106). Thus, with this operation gestalt, the output value of a level meter 122 is judged by investigating for whether the tracking error is contained in the tolerance below a predetermined value in the upper limit of received frequency. As shown in drawing 2, change of the output value of a level meter 122 becomes gently-sloping [near / optimal / the aligning point], but in order for the output value of a level meter 122 to decline greatly as it separates from the optimal aligning point, it can be easily judged only by referring to only the output value of this level meter 122 whether the tracking error became large across tolerance.

[0051] When a tracking error becomes large and the output value of a level meter 122 falls below to a predetermined value, negative judgment is performed in the judgment of step 106. Next, PC128 A local oscillation frequency is the median f_c of the adjustable range. Upper limit f_{max} Top mean value f_U almost corresponding to middle As DAC input data D1 set up when high The median f_c mentioned above Corresponding DAC input data D0 Predetermined value d0 The value subtracted and added is set up (step 107) and this set point is written in EEPROM84 in a control section 8 (step 108).

[0052] In addition, DAC input data D0 It receives and is this predetermined value d0. DAC input data D1 added or subtracted By inputting into DAC4 Upper limit f_{max} of the adjustable range of a local oscillation frequency The value of d0 which it sets and a tracking error becomes below a predetermined value is calculated beforehand. Upper limit f_{max} When the tracking error which can be set is large the value of DAC input data -- this upper limit f_{max} the frequency of the predetermined range to include -- setting -- D0 from -- D1 only changing -- median f_c from -- upper limit f_{max} The tracking error in the range to a value can be held down now to below a predetermined value.

[0053] Moreover, upper limit f_{max} of a local oscillation frequency When a corresponding tracking error is small and the output value of a level meter 122 is beyond a predetermined value, affirmative judgment is performed in the judgment of step 106. next, PC128 -- a local oscillation frequency -- median f_c of the adjustable range Upper limit f_{max} Top mean value f_U almost corresponding to middle DAC input data D1 set up when high ***** -- The median f_c mentioned above Corresponding DAC input data D0 The same value is set up (step 109) and this set point is written in EEPROM84 in a control section 8 (step 110).

[0054] Thus, upper limit f_{max} of a local oscillation frequency After setting processing of corresponding DAC input data is completed, it is the lower limit f_{min} of a local oscillation frequency at the same point. Setting processing of corresponding DAC input data is performed. That is, PC128 sends directions to the test signal generator 126, and inputs the test signal of the same frequency as the lower limit of the adjustable range of the received frequency of FM receiver 100 into FM receiver 100 (step 111). Moreover, PC128 sends directions to a control

section 8, and is the lower limit f_{min} of the adjustable range of a local oscillation frequency. A local oscillation frequency is set up so that it may become a corresponding frequency (step 112). [0055] Thus, lower limit f_{min} of received frequency After various kinds of corresponding setup is completed, PC128 incorporates the output value of a level meter 122, and judges whether this value is beyond a predetermined value (step 113). When a tracking error becomes large and the output value of a level meter 122 falls below to a predetermined value, negative judgment is performed in the judgment of step 113. Next, PC128 a local oscillation frequency -- median f_c of the adjustable range Lower limit f_{min} Bottom mean value f_L almost corresponding to middle DAC input data D2 set up when low ***** -- The median f_c mentioned above Corresponding DAC input data D0 Predetermined value d_1 The value subtracted and added is set up (step 114) and this set point is written in EEPROM84 in a control section 8 (step 115).

[0056] In addition, addition-and-subtraction value d_0 mentioned above It is the DAC input data D0 similarly. It receives and is this d_1 . DAC input data D2 added or subtracted By inputting into DAC4 Lower limit f_{min} of the adjustable range of a local oscillation frequency d_1 which it sets and a tracking error becomes below a predetermined value The value is calculated beforehand. Lower limit f_{min} When the tracking error which can be set is large the frequency of the predetermined range which includes the value of DAC input data for this lower limit f_{min} -- setting -- D0 from -- D2 only changing -- median f_c from -- lower limit f_{min} The tracking error in the range to a value can be held down now to below a predetermined value.

[0057] Moreover, lower limit f_{min} of a local oscillation frequency When a corresponding tracking error is small and the output value of a level meter 122 is beyond a predetermined value, affirmative judgment is performed in the judgment of step 113. next, PC128 -- a local oscillation frequency -- median f_c of the adjustable range Lower limit f_{min} Bottom mean value f_L almost corresponding to middle DAC input data D2 set up when low ***** -- The median f_c mentioned above Corresponding DAC input data D0 The same value is set up (step 116) and this set point is written in EEPROM84 in a control section 8 (step 117).

[0058] Drawing 6 and drawing 7 are drawings showing the relation of the adjustable range of a local oscillation frequency and tracking error in FM receiver 100 of this operation gestalt. As shown in drawing 6 , it is the median f_c of a local oscillation frequency. DAC input data D0 which it sets, adjustment is performed so that a tracking error may become min, and is inputted into DACs 4 and 6 Since it is set up, the tracking error in this frequency hardly exists. Moreover, this median f_c A difference with an actual local oscillation frequency carries out for becoming large, and, as for backlash, a tracking error also becomes large. And as shown in drawing 6 , it is the upper limit f_{max} of a local oscillation frequency. Or lower limit f_{min} When the tracking error which can be set exceeds the predetermined value ϵ Median f_c DAC input data D0 corresponding to the frequency range to include The DAC input data D1 of a different value, and D2 Top mean value f_U The above frequency range or bottom mean value f_L Since it is set up in the following frequency ranges, Tracking adjustment is made as are shown in drawing 7 , and the tracking error in each of these frequency ranges becomes below the predetermined value ϵ . [0059] Thus, tracking adjustment of FM receiver 100 of this operation gestalt is the median f_c of a local oscillation frequency. It sets, measurement using a distortion meter 120 and a level meter 122 is only performed, and large compaction of the measuring time by having reduced the count of the distortion-rate measurement which requires comparatively long time amount for measurement is attained.

[0060] Next, the actuation in the case of receiving FM broadcast wave using FM receiver 100 with which it did in this way and tracking adjustment was performed is explained briefly. When

a predetermined electric power switch (not shown) is operated and it is in the condition that FM receiver 100 can operate, MPU81 in a control section 8 judges whether the control unit 83 was operated and modification of received frequency was directed. When modification of received frequency is directed, MPU81 calculates the division ratio of the counting-down circuit 32 required in order to generate the local oscillation frequency corresponding to the received frequency after modification, and sets this calculated division ratio to a counting-down circuit 32. Moreover, MPU81 is the DAC input data D0 which judges and corresponds [to which frequency band shown in drawing 7 the local oscillation frequency corresponding to the received frequency after this modification belongs, and], D1, and D2. Either is inputted into each of DACs 4 and 6. A tracking error when this receives FM broadcast wave of new received frequency is controlled below at a predetermined value, and can maintain a good receive state in the whole region of a receiving band.

[0061] Especially FM receiver 100 of this operation gestalt has realized the VCO resonance circuit 91 included in a local oscillator 3, and two RF tuning circuits 20 and 24 included in the RF receiving circuit 2 by the similar configuration, when the control voltage V_c moreover generated within a local oscillator 3 changes, the tuning voltage V_{t1} and V_{t2} impressed to each RF tuning circuits 20 and 24 also changes so that this may be interlocked with, and change of tuning frequency is controlled. For this reason, a special temperature-compensation circuit becomes unnecessary. Moreover, since each of DACs 4 and 6 is operating considering the control voltage V_c impressed from a local oscillator 3 as reference voltage, even if it is a case with the unstable supply voltage of FM receiver 100, it cannot be influenced [the] and can prevent increase of the tracking error by fluctuation of supply voltage.

[0062] In addition, this invention is not limited to the above-mentioned operation gestalt, and various deformation implementation is possible for it within the limits of the summary of this invention. For example, at the operation gestalt mentioned above, it is the upper limit f_{max} of a local oscillation frequency. Or lower limit f_{min} It sets. When the tracking error measured based on the output value of a level meter 122 exceeds a predetermined value The median f_c of a local oscillation frequency DAC input data D0 set up by corresponding The DAC input data D1 for which it asked instead so that a tracking error might become below a predetermined value beforehand, and D2 Although it was made to use These upper limits f_{max} Or lower limit f_{min} It carries out adjustable [of the value of DAC input data], setting, acquiring the output value of a level meter 122, and supervising the amount of tracking errors. You may make it a tracking error measure the value of the suitable DAC input data which becomes below a predetermined value each time.

[0063] moreover -- the operation gestalt mentioned above -- a local oscillation frequency -- top mean value f_U Bottom mean value f_L when high time it is low -- the need -- responding -- the value of DAC input data -- D0 from -- D1 1 time or D0 from -- D2 Although it was made to change only once, it is alike, respectively, it sets and you may make it change the value of DAC input data twice or more.

[0064] Moreover, although the operation gestalt mentioned above explained the case where tracking adjustment of FM receiver 100 was performed, this invention is applicable also about the receiver of others which adopted the TERODAIN method to the supermarket, for example, AM receiver, a television set, and a cellular phone.

[0065] Moreover, although the tuning voltage V_{t1} and V_{t2} impressed to each of two RF tuning circuits 20 and 24 in the RF receiving circuit 2 was separately generated with the operation gestalt mentioned above, you may make it set up each tuning frequency using the common

tuning voltage V_{t1} by adjusting two RF tuning circuits 20 and the component constant of the component part in 24. In this case, since time and effort required for tracking adjustment also becomes abbreviation half while simplification of circuitry is attained, since DAC6 and the multiplication circuit 7 become unnecessary, the sharp reduction of adjustment working hours performed in the production process of FM receiver 100 is attained.

[0066] Moreover, in case tracking adjustment is performed with the operation gestalt mentioned above, it is Median f_c about a local oscillation frequency. DAC input data D0 with which it sets up, measurement using a distortion meter 120 and a level meter 122 is performed, and a tracking error serves as min. Although the value was calculated, the set point of a local oscillation frequency is Median f_c . It is not limited and you may make it the any value contained in the adjustable range of frequencies other than this. Specifically, the property of the variable capacitance diode contained in the RF tuning circuits 20 and 24 or the VCO resonance circuit 91 etc. showed to drawing 6 -- as -- upper limit f_{max} of a local oscillation frequency. The amount of tracking errors and lower limit f_{min} which can be set the frequency from which the amount of tracking errors is set to 0 when it is made for the amount of tracking errors which can be set to become equal -- median f_c of a local oscillation frequency from -- it may shift in such a case, a local oscillation frequency -- median f_c from -- suitable DAC input data D0 which can lessen a tracking error more throughout the adjustable range of a local oscillation frequency by setting it as the value which shifted only the specified quantity to a top or the down side, and performing tracking adjustment A value can be calculated.

[0067]

[Effect of the Invention] Since tuning voltage is generated based on control voltage according to the receiver of this invention as mentioned above, like the conventional receiver using a digital-to-analog converter, a tracking error does not need to ask for two or more tuning voltage used as min by measurement, and can shorten the time amount which tracking adjustment takes.

[0068] Moreover, according to the tracking adjustment approach of the receiver of this invention, since [of the adjustable range of received frequency] measurement of a tracking error is mostly carried out in a median, the time amount which tracking adjustment takes can be shortened by reducing the count of this measurement.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the configuration of the FM receiver of 1 operation gestalt.

[Drawing 2] It is drawing showing the relation between a distortion meter, and the output value of a level meter and an aligning point.

[Drawing 3] It is the flow chart showing the operations sequence of the tracking adjustment performed by control of PC.

[Drawing 4] It is the flow chart showing the operations sequence of the tracking adjustment performed by control of PC.

[Drawing 5] It is drawing showing the relation between a local oscillation frequency and tuning frequency.

[Drawing 6] It is drawing showing the relation between the adjustable range of a local oscillation frequency, and a tracking error.

[Drawing 7] It is drawing showing the relation between the adjustable range of a local oscillation frequency, and a tracking error.

[Drawing 8] It is drawing showing the configuration of the conventional receiver which adopted the superheterodyne system.

[Drawing 9] It is drawing showing the contents of the data stored in memory.

[Description of Notations]

2 RF Receiving Circuit

3 Local Oscillator

4 Six Digital-to-analog converter (DAC)

5 Seven Multiplication circuit

8 Control Section

9 Mixing Circuit

20 24 RF tuning circuit

31 Voltage Controlled Oscillator (VCO)

32 Counting-down Circuit

33 Reference Signal Generator

34 Phase Comparator

35 Low Pass Filter (LPF)

81 MPU

82 Interface Section (I/F)

84 EEPROM

91 VCO Resonance Circuit

92 Amplifier

120 Distortion Meter

122 Level Meter

126 Test Signal Generator

128 Personal Computer (PC)

[Translation done.]